

ray may be so branched no less than the others. It is to be hoped that more specimens of this species may be found, so that this question may be settled; for it is very remarkable that the same species should combine such regularity in the pinnules with irregularity in the arm-branching.

The anterior side of the *Ventral Sac* is partly exposed in the proximal region, and is composed of small plates, which, like the covering-plates, seem to run without distinction into those of the *Tegmen*. Where the plates are disturbed, traces of an articular facet can be distinguished on their upper sides, corresponding to the ridge. (Fig. 2.)

The *Stem* is pentagonal or slightly quinquelobate, the lobes being interradial in position, while the radial sutures are seen to run down the depressions between them. The ossicles are all ridged, but alternate in size. The width of the stem is 3·2 millim. and the average height of the ossicles is ·36 millim. (Fig. 1.)

Compared with the stem of *B. quinquelobus*, that of the present species is seen to be proportionally more slender and less lobate. All the ossicles, instead of only alternate ones, are ridged, while the ridges are more obvious in the depressions and are of a finer appearance.

The *Horizon* of the present specimen is more compatible with its stage of development than that to which the type specimen was, perhaps erroneously, assigned.

EXPLANATION OF PLATE XI.

Botryocrinus quinquelobus, sp. n.

Fig. 1. a/435, Woodwardian Museum, No. 1. Seen from anterior; with drawing of transverse section of the stem. Nat. size.

Fig. 2. a/435, Woodwardian Museum, No. 2. Seen from anterior. Nat. size.

Mastigocrinus loreus, gen. et sp. n.

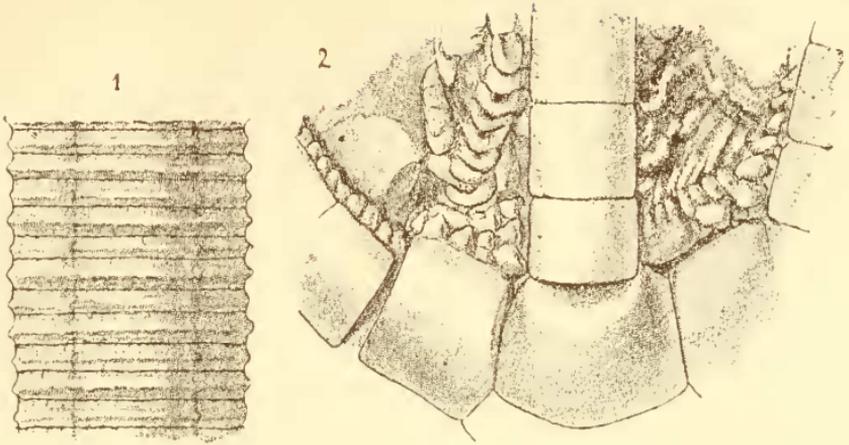
Fig. 3. a/493, Woodwardian Museum. (*Cyathocrinus arboreus*, Salter, Cat.) Seen from right posterior interradius. Nat. size.

All figures on this Plate are from drawings by Mr. E. Wilson, Artist to the Cambridge Engraving Co.

XXXI.—*British Fossil Crinoids*.—VII. *Mastigocrinus loreus*, nov. gen. et sp., *Wenlock Limestone, Dudley*. By F. A. BATHER, M.A., F.G.S.

[Plate XI. fig. 3, and Plate XII.]

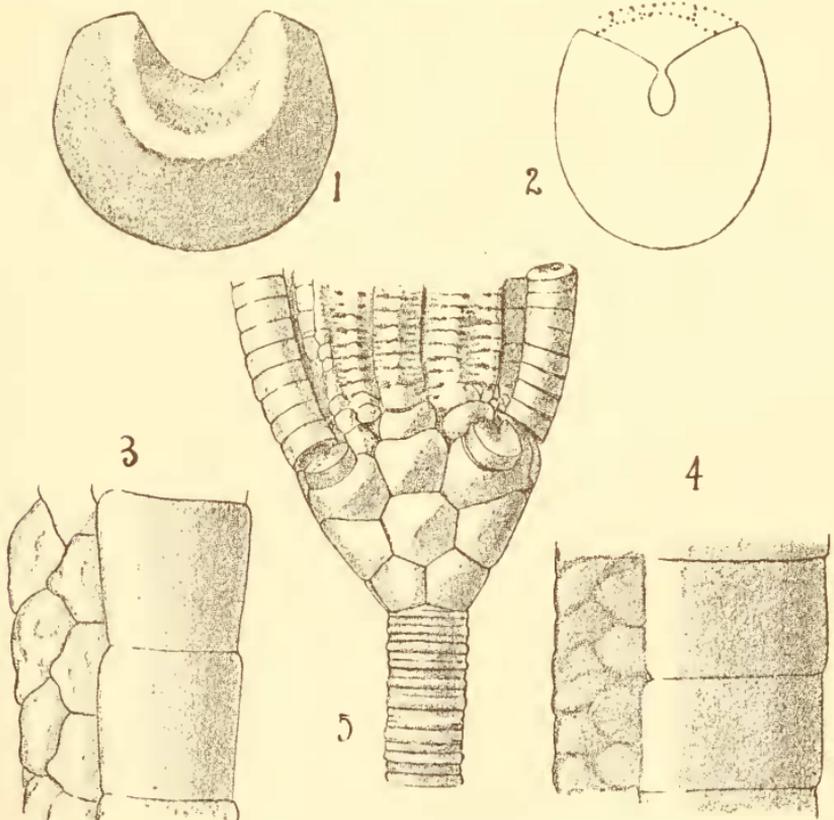
THE form described in this paper appears to belong to the family *Dendrocrinidæ*, series *Dendrocrinites*. It should therefore have been considered before the *Botryocrinites*,



BOTRYOCRINUS PINNULATUS.

Fig. 1. Part of the stem, at about one inch from the crown. ($\times \frac{1}{3}$ diam.)

Fig. 2. Part of the crown, showing the l. ant., ant., and r. ant. Radials and Tribrachia with Covering-plates; also the anterior side of the Ventral Sac and some plates of the Tegmen. ($\times 5$ diam.)



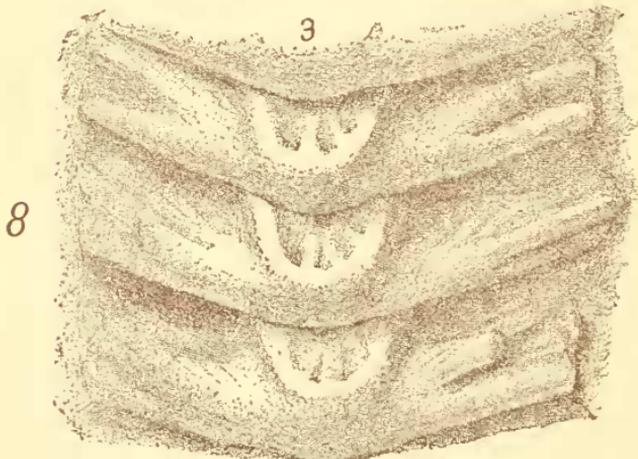
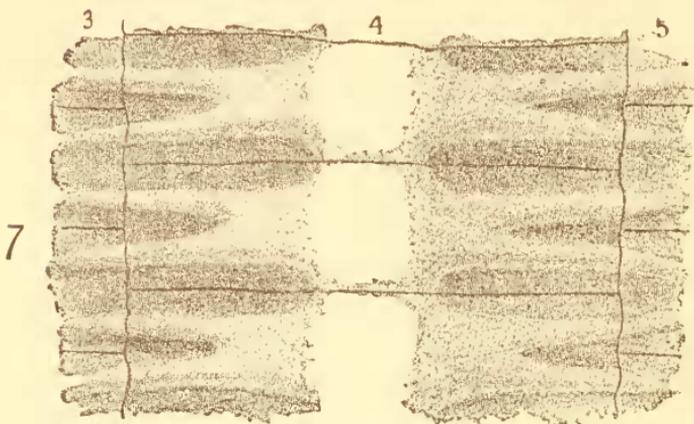
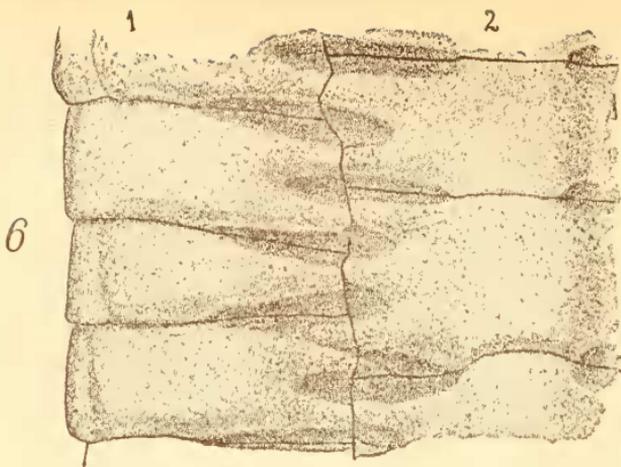
MASTIGOCRINUS LOREUS.

Fig. 1. Anterior facet of l. post. R. from the smaller Dudley Museum specimen. ($\times 10$ diam.)

Fig. 2. Section across a brachial; diagrammatized from the larger Dudley Museum specimen. ($\times 10$ diam.)

Figs. 3 & 4. Portions of arms showing covering-plates, from 133, Mason College. ($\times 20$ diam.) Fig. 4 is the wrong way up by mistake.

Fig. 5. Proximal region of crown and stem, from posterior. 57048, B.M. ($\times 2$ diam.)



STRUCTURE OF THE VENTRAL SAC IN *MASTIGOCRINUS*.

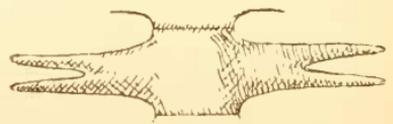
Fig. 6. From distal third, on left edge of sac.

Fig. 7. From proximal third, showing plates in normal position.

Fig. 8. From proximal third, showing plates disturbed and exposing articular facets.

All figures taken from 57048, B.M., and enlarged 20 diam. The small numbers refer to the ridges, as numbered in the text, p. 198.

The *remarque* represents the artist's first and erroneous impression of the structure.



which come in the family Decadocrinidæ. There are two reasons why this was not done: first, that every one who has seen this species, including myself, has regarded it as a *Cyathocrinus*; second, that, until the genera *Botryocrinus* and *Cyathocrinus* were understood, the reasons for separating it from the latter genus would hardly have been appreciated.

Of the genus only the one species is as yet known, though it is probable that several American species will be found to belong to it. The descriptions of genus and species must therefore go together, and a diagnosis of the latter can hardly be given.

GENERIC DIAGNOSIS.

Cup cyathiform, with plates of medium thickness. I BB 5; BB 5; RR 5. Arms simple, dichotomous, elongate. No R'; x hexagonal, in line with RR; Ventral Sac long, flattened, composed of primitively hexagonal plates which are transversely folded. Tegminal plates small, irregular. Stem round, with small pentagonal axial canal, and with radial sutures.

The appearance of the specimens as they lie on the rock, with their long, wavy, delicate arms outstretched, suggests a knout or cat-o'-nine-tails; hence the name, from $\mu\acute{\alpha}\sigma\tau\iota\xi$, a scourge.

The type species is founded on the evidence of five specimens, viz. :—

In the British Museum :

57048, a magnificently preserved crown, with 36 millim. of stem, seen from the posterior. Matrix a blue shale. Dudley. From the collection of Mr. John Gray of Hagley. (Pl. XII. fig. 3, and zincotype, figs. 3-8, and fig. 9 on p. 198.)

In the Museum of Mason College, Birmingham :

133, a fairly complete crown, with 24 millim. of stem; seen from left side; rather disturbed and overgrown by Polyzoa. Matrix a rough limestone. Dudley. (Pl. XII. fig. 2.)

In the Museum of the Dudley Geological Society :

(a), a portion of a crown, with traces of ventral sac and 66 millim. of stem; seen from anterior. Matrix a blue shale. Dudley. (P. 200, fig. 10.)

(b), a smaller crown broken distally, with 8 millim. of stem, seen from posterior. Matrix a blue shale. Dudley. (Pl. XII. fig. 1, and zincotype, fig. 1.)

In the Woodwardian Museum, Cambridge :

a/493, an almost complete specimen, with the crown slightly disturbed; seen from right posterior radius. On a slab of limestone. Dudley. In the Fletcher collection. (Pl. XI. fig. 3, explanation on p. 194.)

For permission to figure the first and last of these specimens my thanks are here given to Dr. Henry Woodward, F.R.S., and Prof. T. McKenny Hughes. For similar favours, as well as for the loan of the specimens in the Mason College and the Dudley Museums, I must express my gratitude to Prof. C. Lapworth and Mr. W. Madeley.

These specimens all appear to come from the Upper Wenlock Limestone; but, as usual, their exact locality and horizon are uncertain. They all belong to one species, for which I propose the name—

Mastigocrinus loreus, sp. n.

1873. *Cyathocrinus* (sp. 9) *arboreus*, J. W. Salter, *nom. nud.*, Cat. Camb. and Sil. Foss. p. 125: Cambridge.

Non *Cyathocrinus arboreus*, Meek and Worthen, Proc. Acad. Nat. Sci. Philadelphia for 1865, p. 160, and Rep. Geol. Surv. Illinois, vol. iii. p. 520 (1868).

Cyathocrinus sp. 11, Salter, *loc. cit.*

The trivial name applied to this species means "provided with lashes," and, besides carrying on the metaphor of the generic name, it alludes to the very fine terminations of the arms.

DETAILED DESCRIPTION.

The plates of all the specimens except 57048 B.M. are somewhat displaced, so that the measurements here given refer chiefly to that. For details connected with the Cambridge specimen I am indebted to drawings furnished by Mr. Edwin Wilson, as well as to an excellent photograph sent me by the Cambridge Engraving Co.: the specimen itself I have never seen, as it could never be found when I went to the Woodwardian Museum; for information that it was at last forthcoming I am obliged to Mr. H. Woods. The specimen a/497 which Salter labelled "*Cyathocrinus* sp. 11," was also thought to be missing (see Cat. Type Fossils, Woodwardian Mus. p. 39, Cambridge, "1891," 1892); but, through the kindness of Mr. Woods in sending me a rough sketch of it, I am able to refer it, as was to be anticipated, to the present species. The specimen consists of a rather disturbed crown,

with 10 millim. of stem, and it shows the delicate finials very well. It is on a large block of limestone, and comes from the Fletcher collection.

Dorsal cup conical, slightly expanding above, much as in *Botryocrinus decadactylus*. The plates are smooth or very finely shagreened, and almost plane. Measurements are:— Height along posterior interradius, 10 millim.; width below, 5·2 millim.; width above, 14 millim., but some of this is due to crushing.

IBB 5, pentagonal, forming a very slight angle with the stem. Measurements are:—

	Height. millim.	Width below. millim.	Width above. millim.
57048 B.M.	3·5	3	3·2
" "	3	3	3·2

In smaller specimens they are rather larger in proportion.

BB 5; 4 are hexagonal, post.B heptagonal. Measurements:—

	Height. millim.	Width below. millim.	Width above. millim.
57048 B.M.	4·5	3·5	4·25 (post.B)
" "	4·75	?	? (r. post.B)

In smaller specimens they are rather larger in proportion.

RR 5, of normal shape; bending outwards towards the facet and curving inwards towards the radial processes, as in *Botryocrinus*. Measurements are:—

	Height. millim.	Width below. millim.	Width above. millim.	Width of facet. millim.
57048 B.M.	3·5	5	5 (?)	4
Cambridge	4	4·9	4·9	3·1

The articular facet (zincotype, fig. 1) has a very faint transverse ridge and the axial canal is not separate.

The Arms are about 11 times as long as the height of the cup; they dichotomize at least 8 times, at rather long intervals, and decrease very gradually both in the diameter and height of the ossicles. All this gives them an exceedingly slender and graceful appearance, especially when they have a delicate wave as in 57048 B.M. Corresponding branches are equal in size, except perhaps occasionally in the extreme distal region, where one branch sometimes appears to be smaller than its fellow.

The ventral groove is a slight wide depression, from which a narrow V stretches to the axial canal which is not separated by stereom (zincotype, fig. 2). The covering-plates are

irregular and numerous, as in *Botryocrinus*, but appear to be more or less alternating (zincotype, figs. 3 and 4).

The total length of the arms in 57048 B.M. is 11 centim.

I Br number from 7 to 11, the usual number being 8. Their height is 1.4 millim. ; their width 3 millim.

II Br 9, 10, or 11.

III Br from 9 to 14.

IV Br from 12 to 26.

V Br numbers noted 17 and 22.

VI Br numbers noted 16 and 25.

VII Br 15 observed.

VIII Br and IX Br are so small and faint that it is difficult to make out their exact numbers. The width of the finials is about .25 millim. The distal portions of an arm-branch are figured here (fig. 6), to show that there is no suspicion of pinnules.

Anal structures.—Anal *x* is hexagonal, resting on the horizontal upper side of post. B, in a line with RR, and supporting three plates, viz. a median proximal plate of similar shape and a small plate on either side between it and the adjacent radials (*rt* and *lt*).

The Ventral Sac in 57048, where it is magnificently displayed, has a length of 7 centim. At its origin it is 10 millim. wide, but rapidly increases to 13 millim. and then decreases very gradually. It is transversely compressed and is very flat.

In its plan of structure this sac resembles those of *Thenarocrinus*, *Botryocrinus*, and *Dendrocrinus* (what may be called the wickerwork-type, Trautschold's "Angulosi"). Seen from the posterior, 5 ridges are visible, which are from left to right as follows:—(1) ridge starting from *lt*, (2) ridge starting from a plate intercalated between *lt* and median proximal plate, (3) median ridge, starting from median proximal plate, (4) ridge starting from *rt*, (5) ridge on right of *rt* ridge. There are probably three other ridges on the anterior side. This would make the number of ridges 8 in all, in which the genus would agree with *Thenarocrinus* if not with others of the group.

The ossicles are slightly ridged in the middle, and are

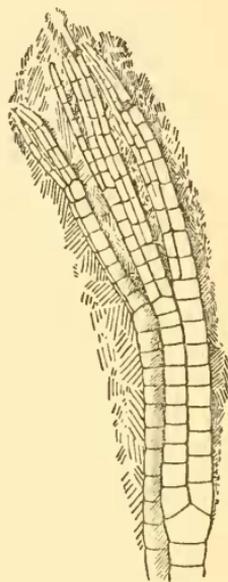


Fig. 9.—*M. loreus*. Distal end of part of l. post. Arm in 57048 B. M. ($\times 6\frac{2}{3}$ diam.)

thrown into strong lateral folds. Primitively the ossicles are hexagonal in outline and alternate with those of adjacent rows, but the simple outline is usually obscured by the folding. The folds on one side of one ossicle usually meet the folds on the adjacent side of two adjoining ossicles. Sometimes, however, there appear to be small intervening plates, in which the folds of the ossicles on either side meet. The stereom is perfectly continuous over the whole surface of the ventral sac, forming the floor of the depressions just as much as the summits of the folds and ridges (zincotype, figs. 6 and 7). That the sac was a very flexible structure is proved by the appearance presented by the upper and lower sutural surfaces of the individual ossicles: when the ossicles are slightly pushed over so as to expose these edges, it is seen that the end of each ridge is a regular articular facet of almost circular outline, marked with depressions for ligament, which depressions run at right angles to the surface of the sac (zincotype, fig. 8). The plates that form ridges 2, 3, and 4 are more or less flat; but those forming ridges 1 and 5, which are at the borders of the sac, are bent round at a sharp angle, the angle itself being rounded and constituting the ridge. In other words, these two ridges form part of both the anterior and the posterior surfaces of the sac. The following are measurements of ossicles from the proximal region of the sac:—In the median ridge (3), height .83 millim., width 3 millim.; in ridges 2 and 4, height .7 millim., width 2.6 millim. The ossicles decrease in all dimensions in the distal region of the sac.

The description of the Ventral Sac has been given at considerable length, as the specimen 57048 B.M. shows the structure of this interesting organ more clearly than any other fossil known to me. It is perfectly certain that there are no slits or pores of any kind in this sac; and yet so deceptive is the appearance of the depressions filled with matrix that both Mr. Hollick and Mr. Wilson, experienced scientific artists, drew the plates as though they were quite discontinuous, and as though there were large slits between the folds or finger-like processes. Now, however, Mr. Hollick, after examining the whole surface of the sac with a microscope, and after seeing the matrix cleaned out with needle and brush from some of the most slit-like depressions, is so convinced of his former error that he will hardly permit me to publish the drawing that he first made. This, however, I give in the margin, in order to show how the most careful observer may be misled. These facts seem sufficient explanation of those statements, so often controverted in the present series of papers, as to the presence of slits in the ventral sac of the *Fistulate Crinoids*.

The Stem attained a length of at least 11 centim. It was round in section, with a width (in 57048) of about 4·5 millim. In the proximal region it is composed of ossicles of three sizes, the larger ones slightly projecting, with an average height of ·4 millim. (zincotype, fig. 5). In the more distal regions (fig. 10) the ossicles are smooth and more equal in height. The sutures are crenulate, indicating radiate striæ on the articular surface. The lumen is small, as in *Botryocrinus*, and from it there proceed five radial sutures, which are usually visible on the outside right up to the dorsal cup. In the distal region of the stem the pentameres show only a slight tendency to the hexagonal shape and semi-alternating arrangement described for *Botryocrinus*. The distalmost end of the Cambridge specimen is smooth and rounded, and this though the whole stem and cup are very slightly disturbed. If this rounding be due to weathering, it would appear to have been accomplished while the creature was yet alive. (Pl. XI. fig. 3.)

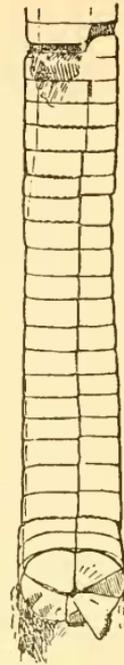


Fig. 10.—Distal part of Stem in the larger Dudley Museum specimen of *M. loreus*. ($\times 3\frac{1}{2}$ diam.)

GENERAL REMARKS ON THE GENUS.

In the composition of its cup, in the anal area, and in the simple dichotomy of its arms, this species resembles the species of *Cyathocrinus*, and, were that genus not more strictly defined than it has hitherto been, it would doubtless be referred thither. On the other hand, there are many points, not hitherto recognized as of great importance, in which the present species resembles a very different assemblage of Crinoids. The shape of the cup, especially of the radials, is the same as that of *Botryocrinus*. The ventral sac is of the same structure as that of *Dendrocrinus*, *Botryocrinus*, and *Thenarocrinus*; while the general resemblance of the smaller Dudley specimen to the type specimen of *T. gracilis* (Brit. Foss. Crin. IV., 'Annals,' ser. 6, vol. vii. pl. i. fig. 4) cannot pass unnoticed. The arms are especially like those of *T.*